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[Title of the Invention] SEMICONDUCTOR DEVICE AND METHOD OF MANUFACTURING THE SAME

[Claim for a Patent]

[Claim 1] A semiconductor device, comprising at least:

a semiconductor region;

a boron-doped phosphorus silicate glass (BPSG) film formed over the semiconductor region; and

an oxide film containing nitrogen formed between the semiconductor region and the boron-doped phosphorus silicate glass film.

[Claim 2] The semiconductor device according to claim 1, having a maximum value that a nitrogen concentration distribution in a thickness direction of the oxide film is set to a maximum value.

[Claim 3] A method for manufacturing a semiconductor device, comprising at least the steps of:

forming an oxide film containing nitrogen over a semiconductor region;

forming a boron-doped phosphorus silicate glass film over the oxide film; and

heat-treating the boron-doped phosphorus silicate glass film in an oxidizing atmosphere.

[Claim 4] A method for manufacturing a semiconductor device according to claim 3, wherein a dinitrogen monoxide (N_2O) gas or a nitric monoxide (NO) gas is used in the step of forming the oxide film.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a semiconductor device having a BPSG (boron-doped phosphorus silicate glass) interlayer insulating film, and particularly, to a reduction in an oxidization of a semiconductor substrate or the like during a reflow process.

[0002]

[Prior Art]

With a high integration of a semiconductor device, a reduction in temperature and a reduction in time in a heat treatment are demanded in order to restrict an extension of a diffusion layer to a minimum, while the design rules become strict. Therefore, a pattern of a high aspect ratio is required to bury without voids with respect to an interlayer insulating film. Then, in a boron-doped phosphorus silicate glass (hereinafter referred to as the "BPSG") which is widely used as the interlayer insulating film and is a phosphorus glass obtained by doping boron (B) in an oxide film, a reflow process in a vapor atmosphere is carried out so as to carry out a reflow process at low temperatures and in a short time. However, since the heat treatment is carried out in an oxidizing atmosphere, a semiconductor region is oxidized in this condition. Then, a nitride film having a strong oxidization resistance is formed in a lower layer of the BPSG layer to prevent an oxidization of silicon (Si) in the lower layer of the BPSG film.

[0003]

However, since ammonia (NH_3) serving as a raw material gas for a film formation and hydrogen included in dichlorosilane

(SiH_2Sl_2) are taken in the nitride film, when the nitride film is formed surrounding a gate electrode of a transistor, this is a cause of lowering the reliability of a gate oxide film and in some cases, the nitride film is not allowed to form according to the semiconductor device. In such the case, the reflow process cannot be carried out in the vapor atmosphere and a change of the design rules and the process was needed in order to avoid this.

[0004]

[Problems to be Solved by the Invention]

The present invention was made in view of the above-mentioned circumstances, and it is an object of the present invention to provide a semiconductor device in which a reflow process of a BPSG film in a vapor atmosphere can be carried out with respect to a semiconductor device which has a problem on hydrogen in a nitride film and cannot form the nitride film.

[0005]

It is another object of the present invention to provide a method for manufacturing a semiconductor device in which a reflow process of a BPSG film in a vapor atmosphere can be carried out with respect to a semiconductor device which has a problem on hydrogen in a nitride film and cannot form the nitride film.

[0006]

[Means for Solving the Problems]

In order to accomplish the above objects, according to a first aspect of the present invention, the semiconductor device comprises at least: a semiconductor region; the BPSG film

formed over the semiconductor region; and an oxide film containing nitrogen formed between the semiconductor region and the BPSG film. Here, the semiconductor region may be a semiconductor substrate, an epitaxial film or a polysilicon film. A monocrystal silicon is typical as the semiconductor substrate. Further, the oxide film containing nitrogen is a film in which, if the oxide film is a silicon oxide film, a covalent bond of silicon atoms and oxygen atoms is replaced with the covalent bond of silicon atoms and nitrogen atoms. The nitrogen atom can be replaced with the oxygen atom bonded to the silicon atom by heating, but the oxygen atom is hard to be replaced with the nitrogen atom bonded to the silicon atom. As a film structure obtained by bonding the silicon atom to the nitrogen atom is dense for the oxygen atom, the oxygen atom is hard to diffuse the inside of this film. As the film structure obtained by bonding the silicon atom to the oxygen atom is coarse for the nitrogen atom, the nitrogen atom is easy to diffuse the inside of this film. From this phenomenon, it can be found that an insertion of the nitrogen film is effective for restricting an oxidization of the semiconductor region in a reflow process of the BPSG film, but even if a partial oxygen atom in the oxide film is replaced with the nitrogen atom, an effect of the restriction appears. The semiconductor device which can reflow the BPSG film in the oxidizing atmosphere is provided by utilizing these.

[0007]

Further, according to the first aspect of the present invention, it is effective to have a maximum value so as to set the nitrogen concentration distribution in the thickness direction of the oxide film to a maximum value. Here, to have the maximum value in which the nitrogen concentration distribution becomes a maximum value means that nitrogen is distributed over even a part in the thickness direction of the oxide film. Namely, if a layer which is hard to diffuse exists

in a part of a diffusion path of the oxygen atom, the diffusion is suppressed as a whole. Therefore, if the partial oxygen is replaced with nitrogen in a partial layer in the oxide film, an effect of suppressing the oxidization is caused. In particular, the greater the maximum value as a peak value is, the greater the effect of suppressing the oxidization in the semiconductor region is. Thus, even if a nitrogen amount is small as a whole, the large effect of suppressing the oxidization can be obtained.

[0008]

According to a second aspect of the present invention, the method for manufacturing a semiconductor device comprises at least the steps of: forming an oxide film containing nitrogen over a semiconductor region; forming a BPSG film over the oxide film; and heat-treating the BPSG film in an oxidizing atmosphere. Thus, even in the heat treatment in the oxidization atmosphere, as an oxide seed is hard to diffuse the oxide film containing nitrogen, the oxidization of the semiconductor region is suppressed in the reflow process of the BPSG film.

[0009]

According to the second aspect of the present invention, in the process of forming the oxide film, it is more effective to use a dinitrogen monoxide (N_2O) gas or a nitric monoxide (NO) gas. As a material gas does not contain hydrogen, it becomes possible to form the film containing nitrogen which prevents a diffusion of the oxidizing seed with respect to the semiconductor device which has a problem on hydrogen in the nitric film and cannot form the nitride film. It is possible to provide the method for manufacturing the semiconductor device which can reflow the BPSG film in the oxidizing atmosphere.

[0010]

[Preferred Embodiments]

Hereinafter, an embodiment of the present invention will be described with reference to the drawings. In the below description of the drawings, the identical or similar reference numerals are applied to the identical or similar portions. It is to be noted that the drawings are schematic and a relation between a thickness and a plan dimension or a ratio to a thickness of each layer is different from the actual one. Accordingly, a concrete thickness or dimension should be determined in view of the below description. Further, a relation of mutual dimensions or a portion of a different ratio is included between the mutual drawings, as a matter of course.

[0011]

(First Embodiment)

Fig. 1 is a sectional view showing a semiconductor device according to a first embodiment of the present invention. The semiconductor device according to the first embodiment of the present invention has a silicon substrate 1 for providing semiconductor regions, a BPSG film 7 formed over the silicon substrate 1, and a nitrogen-containing oxide film 6 formed between the silicon substrate 1 and the BPSG film 7 and serving as an oxide film containing nitrogen. Although not shown in Fig. 1, the silicon substrate 1 has active regions and electrode regions for transistors. On the silicon substrate 1, a gate oxide film 2 is formed. On the gate oxide film 2, a gate electrode obtained by laminating a polysilicon film 3 and a silicide film 4 made of a high melting point metal film or high melting point metal is formed. On the gate electrode, a nitride film or an oxide film 5 is formed as an ion implanting mask in forming an electrode region. The silicon substrate 1, the gate

oxide film 2 laminated, the polysilicon film 3, the silicide film 4 made of the high melting point metal film or high melting point metal, and the nitrogen-containing oxide film 6 covering a surface of a nitride film or oxide film 5 are formed. A BPSG film 7 is formed on the nitrogen-containing oxide film 6. It is to be noted that tungsten (W), titanium (Ti), molybdenum (Mo) or cobalt (Co) is used. As silicide of the high melting point metal, tungsten silicide (WSi_2), titanium silicide ($TiSi_2$), molybdenum silicide ($MoSi_2$), or cobalt silicide ($CoSi_2$) is used.

[0012]

Fig. 2 is a diagram showing a nitrogen concentration in the nitrogen-containing oxide film 6 and a distribution in a depth direction of the number of count of oxygen secondary ions in a semiconductor device according to the first embodiment of the present invention. These distributions are results obtained by analyzing in the depth direction by a secondary ion mass spectrometry (SIMS) in which cesium ions (Cs^+) are used as primary ions. The transverse axis denotes a depth from a surface contacting with a BPSG film of the nitrogen-containing oxide film 6 to the silicon substrate 1 and a measuring time counted from the surface. The longitudinal axis denotes the number of count of the nitrogen concentration in the film and the oxygen secondary ions. A triangle mark in Fig. 2 denotes the nitrogen concentration in the film and a square mark denotes the number of count of the oxygen secondary ions. It is to be noted that a position of an interface between the nitrogen-containing oxide film 6 and the silicon substrate 1 in Fig. 2 is decided from a distribution in the depth direction of the number of count of the oxygen secondary ions and a measurement of the depth of a hole sputtered after analyzed by the SIMS method. The semiconductor device according to the first embodiment of the present invention has a maximum value in which a nitrogen concentration distribution in a thickness direction of the nitrogen-containing oxide film 6 is a peak

value. That is, the nitrogen concentration in the film is almost in a maximum in the center of the nitrogen-containing oxide film 6. The maximum nitrogen peak concentration in the film was 2.7atm%. If stoichiometry is proper in a silicon nitride film (Si_3N_4), the value is 57atm%, but 2.7atm% is a value of about a half thereof. Further, a minimum value of the nitrogen concentration in the film in the nitrogen-containing oxide film 6 exists near a surface of the film 6, and it was not more than 0.1atm%.

[0013]

Fig. 3 is a diagram showing a relationship between an oxidizing amount of the silicon substrate 1 and the nitrogen peak concentration in the film by a reflow process in the semiconductor device according to the first embodiment of the present invention. The transverse axis denotes the nitrogen peak concentration in the film measured by the SIMS method. The longitudinal axis denotes the oxidizing amount of the silicon substrate 1. A value of the nitrogen peak concentration in the film in Fig. 3 is 0atm% and this value indicates the oxidizing amount when the nitrogen-containing oxide film 6 is not formed. It is to be noted that a film thickness of the nitrogen-containing oxide film 6 is 5nm. Thus, when the nitrogen-containing oxide film 6 is not formed under the BPSG film 7, the silicon substrate 1 is oxidized by about 8nm, and it can be found that if a value of the peak concentration is 1atm%, an effect of suppressing the oxidizing amount is attained. If the peak concentration is 2atm%, the oxidizing amount of the silicon substrate 1 can be reduced down to 2.5nm corresponding to about 1/3 of the above value. The higher the concentration is, the smaller the oxidizing amount become, and when a value of the peak concentration is 3atm%, the oxidizing amount can be reduced down to about 1nm, and when 4atm%, it can be reduced down to about 0.5nm. The oxidizing amount can be further suppressed by raising the peak concentration.

[0014]

A method for manufacturing the semiconductor device according to the first embodiment of the present invention comprises at least the steps of: forming the nitrogen-containing oxide film 6 which is an oxide film containing nitrogen over the silicon substrate 1, forming the BPSG film 7 over the film 6, and heat-treating the BPSG film 7 in an oxidizing atmosphere. In the step of forming the film 6, a N_2O gas is used. The detailed manufacturing method will be shown as follows:

[0015]

(a) First, as shown in Fig. 4(a), the gate oxide film 2 is formed on the silicon substrate 1, and subsequently, the polysilicon film 3, the silicide film 4 made of the high melting point metal film or high melting point metal and the nitride film or the oxide film 5 are deposited. A resist is used as a mask, and the nitride film or the oxide film 5, the silicide film 4 made of the high melting point metal film or high melting point metal, the polysilicon film 3 and the gate oxide film 2 are dry-etched.

[0016]

(b) Next, as shown in Fig. 4(b), the nitrogen-containing oxide film 6 is formed by 5nm at a film thickness on the silicon substrate 1, for example. This nitrogen-containing oxide film 6 is formed by introducing the N_2O gas into a reactive tube controlled to a temperature of 900°C and a pressure of 53.2kPa in 30 minutes. Under this film forming condition, the nitrogen peak concentration in the film was about 2atm%. It is to be noted that this peak concentration can be changed by varying parameters such as a film forming pressure, a film forming

temperature, or a gas passing time of N_2O. Further, the film forming temperature was 900°C, but it is not limited to 900°C, and it may be in the range of 600 to 1000°C. Concerning the film forming pressure also, similarly, it may be from 133Pa to in the range of the atmospheric pressure. As a material gas, etc. containing hydrogen atoms is not used at all in forming the film 6, the hydrogen atoms are entered into the film 6. An exposed surface of the silicon substrate 1 is nitrided and oxidized to form the film 6. In the oxide film 2, nitrogen is diffused from the side to form the film 6 on a side wall. In the polysilicon film 3 and the silicide film 4 made of the high melting point metal film or high melting point metal, the side walls are nitrided and oxidized to form the film 6. Concerning the film 5, when the film 5 is a nitride film, the film 6 is not formed in the film 5, but when it is an oxide film, nitrogen is diffused from the exposed portion to form the film 6.

[0017]

(c) As shown in Fig. 4(c), the BPSG film is formed by 900nm, for example. An embedding is incomplete in between the gate electrodes of a strict aspect and voids 8 are formed.

[0018]

(d) Finally, as shown in Fig. 1, a heat treatment is carried out at 750°C in 30 minutes in a vapor atmosphere. The BPSG film 7 is fluctuated by this heat treatment and as the results, the voids 8 between the gates are vanished. At that time, since the nitrogen-containing oxide film 6 of a lower layer of the BPSG film 7 blocks a diffusion of an oxidizing seed into not only a region contacting with the film 6 of the silicon substrate 1 but also a region contacting with the gate oxide film 2, the oxidizing amount of the silicon substrate 1 can be restricted and an increase in a film thickness of the gate oxide film can be restricted.

[0019]

Fig. 5 is a diagram showing a relationship between a film forming time of the nitrogen-containing oxide film 6 and the nitrogen peak concentration in the film in the semiconductor device according to the first embodiment of the present invention. The transverse axis denotes a time of flowing the N_2O gas in the reactive tube, a so-called film forming time. The longitudinal axis denotes the nitrogen peak concentration in the film measured by the SIMS method. The film forming temperature is 900°C fixed. The film forming pressure is controlled to 26.6kPa, 53.2kPa and 79.8kPa. Thus, it was found that the film forming time is in proportion to the peak concentration. Further, the peak concentration has the dependency on the film forming pressure and it was found that as the pressure is increased, the peak concentration is increased. A desired nitrogen concentration can be obtained by varying the film forming conditions, and it is considered that the film forming time is set to not less than 40 minutes or the film forming pressure is controlled to 79.8kPa, so that the film having the peak concentration of more than 4atm% can be formed.

[0020]

(Second Embodiment)

A method for manufacturing the semiconductor device according to a second embodiment of the present invention differs from the first embodiment of the present invention in that a NO gas is used in a process of forming the film 6. The detailed manufacturing method will be described as follows:

[0021]

(a) First, similarly to the first embodiment shown in Fig. 4(a), the gate oxide film 2, etc. is formed on the silicon substrate 1.

[0022]

(b) Next, as shown in Fig. 6, a thermal oxide film is formed at a film thickness of 5nm on the silicon substrate 1 in the oxygen atmosphere at a temperature of 800°C. The exposed surface of the silicon substrate 1 is oxidized to form the oxide film 2. The side wall of the polysilicon film 3 and the silicide film 4 made of the high melting point metal film or high melting point metal is oxidized to form oxide films 13 and 14. However, the film 5 is not oxidized further.

[0023]

As shown in Fig. 4(b), the exposed oxide film is nitrided. After the pressure in the reactive tube is controlled to be 53.2kPa at a substrate temperature of 800°C, the nitriding is performed by introducing the NO gas in 30 minutes. At this time, since the NO gas itself does not contribute to a formation of the oxide film, an increase in the oxide film thickness is not caused. On the other hand, since nitrogen is taken into the oxide film, the gas passing time of the NO gas is prolonged, thereby raising the nitrogen concentration in the film. Since a nitrogen amount taken into the oxide film in a unit time depends on a process temperature and pressure, these are altered to arbitrarily control the nitrogen peak concentration. As the material gas, etc. containing the hydrogen atoms is not used at all in forming the film 6, the hydrogen atoms are not entered into the film 6. Nitrogen diffuses from the exposed surface of the oxide film 2 to form the film 6. However, nitrogen does not diffuse to the film 2 just under the polysilicon film 3 and the nitriding is not performed. An oxide film 13 made polysilicon and an oxide film 14 made of WSi or W are nitrided

to form the film 6. When the film 5 is a nitride film, the film 6 is not formed in the film 5, but when it is an oxide film, nitrogen diffuses from the exposed portion to form the film 6. It is to be noted that the thermal oxidization and the nitriding by the NO gas may be carried out by an identical device or another device.

[0024]

(c) Similarly to the first embodiment shown in Fig. 4(c), the BPSG film is formed.

[0025]

(d) Finally, similarly to the first embodiment shown in Fig. 1, the heat treatment is carried out in the vapor atmosphere. At that time, since the film 6 of a lower layer of the BPSG film 7 blocks a diffusion of an oxidizing seed to not only the region contacting with the film 6 of the silicon substrate 1 but also the region contacting with the gate oxide film 2, the oxidizing amount of the silicon substrate 1 is restricted and an increase in the film thickness of the gate oxide film can be restricted.

[0026]

(Third Embodiment)

Fig. 7 is a sectional view of a semiconductor device according to a third embodiment of the present invention. In the semiconductor device according to the third embodiment of the present invention, it is formed by using the oxide film obtained by forming the nitrogen-containing oxide film 6 by LP-CVD. A manufacturing method of the semiconductor device according to the third embodiment of the present invention is indicated as follows:

[0027]

(a) First, similarly to the first embodiment shown in Fig. 4(a), the gate oxide film 2, etc. is formed on the silicon substrate 1.

[0028]

(b) Next, as shown in Fig. 8(a), tetramethyl-orthosilicate (TEOS, $Si(OC_2H_5)_4$) and monosilane (SiH_4) are used as the material gas, and the oxide film 15 is formed by LP-CVD at the film thickness of 5nm. The film forming temperature is about 800°C. The oxide film 15 can be formed uniformly on the exposed surface. As shown in Fig. 8(b), the oxide film 15 is nitrided similarly to the second embodiment. It is to be noted that the material gas such as TEOS or monosilane containing the hydrogen atoms is used in forming the oxide film 15, and after a formation of the film 6, the hydrogen atoms scarcely remain in the film.

[0029]

(c) As shown in Fig. 8(c), the BPSG film is formed by the method similar to the first embodiment.

[0030]

(d) Finally, as shown in Fig. 7, the heat treatment is carried out in the vapor atmosphere by the method similar to the first embodiment. At that time, since the nitrogen-containing oxide film 6 of the lower layer of the BPSG film 7 blocks the diffusion of the oxidizing seed to not only the region contacting with the film 6 of the silicon substrate 1 but also the region contacting with the gate oxide film 2, the oxidizing amount of the silicon substrate 1 is restricted and an increase in the film thickness of the gate oxide film can be restricted.

[0031]

(Fourth Embodiment)

Fig. 9 is a sectional view of a flash memory according to a fourth embodiment of the present invention. The flash memory according to the fourth embodiment of the present invention has the silicon substrate 1 serving as the semiconductor region, the BPSG film 7 formed on the silicon substrate 1, and the nitrogen-containing oxide film 6 as the oxide film containing nitrogen formed between the silicon substrate 1 and the BPSG film 7. Further, the gate oxide film 2 is formed on the silicon substrate 1. On the gate oxide film 2, the polysilicon film 3 serving as a floating gate, an oxide film 9, a polysilicon film 10 serving as a control gate, a tungsten silicide (WSi_2) film 11 and an oxide film 12 are stacked to form the gate electrode. The silicon substrate 1 and the nitrogen-containing oxide film 6 coating the surface of the gate electrode are formed. The BPSG film 7 is formed on the nitrogen-containing oxide film 6.

[0032]

A method for manufacturing the flash memory according to the fourth embodiment of the present invention contains at least the steps of: forming the nitrogen-containing oxide film 6 which is the oxide film containing nitrogen over the silicon substrate 1 as the semiconductor region, forming the BPSG film 7 over the film 6, and heat-treating the BPSG film 7 in the oxidizing atmosphere. In the step of forming the film 6, the N_2O gas is used. The detailed manufacturing method will be shown as follows:

[0033]

(a) First, as shown in Fig. 10(a), the gate oxide film 2 is

formed on the silicon substrate 1, and subsequently, the polysilicon film 3, the oxide film 9, the polysilicon film 10, the tungsten silicide film 11 and the oxide film 12 are deposited. The resist is used as a mask, and the oxide film 12 and the oxide film 2 are dry-etched.

[0034]

(b) Next, as shown in Fig. 10(b), the nitrogen-containing oxide film 6 is formed by 5nm at the film thickness on the silicon substrate 1, for example. The forming conditions are similar to the first embodiment. Under this film forming condition, the nitrogen peak concentration in the film was about 2atm%. As the material gas, etc. containing the hydrogen atoms is scarcely used in forming the film 6, the hydrogen atoms are not entered into the film 6.

[0035]

(c) As shown in Fig. 10(c), the BPSG film is formed by the method similar to the first embodiment.

[0036]

(d) Finally, as shown in Fig. 9, the heat treatment is carried out in the vapor atmosphere by the method similar to the first embodiment. Since the nitrogen-containing oxide film 6 of the lower layer of the BPSG film 7 blocks the diffusion of the oxidizing seed into not only the region contacting with the film 6 of the silicon substrate 1 but also the region contacting with the gate oxide film 2, the oxidizing amount of the silicon substrate 1 can be restricted and an increase in the film thickness of the gate oxide film 2 and the oxide film 9 can be restricted.

[0037]

(Other embodiment)

As described above, the embodiments of the present invention were mentioned, but it cannot be understood that the statement and drawings making a part of this disclosure limit the present invention. Various alternative embodiments, examples and operational technologies are clarified to those skilled in the art from this disclosure.

[0038]

In the description of the already mentioned embodiments, the nitrogen-containing oxide film 6 is formed so as to enclose the gate electrode. However, a film corresponding to the nitrogen-containing oxide film 6 is formed as the gate oxide film 2 and the nitrogen-containing oxide film 6 is left behind in dry-etching the gate electrode, and in this case also, the same effect can be attained concerning the oxidization of the silicon substrate.

[0039]

Further, the present invention can be applied to the reflow process of a phosphorus glass (PSG) in addition to the BPSG film, as a matter of course. As the nitrogen-containing oxide film 6 has the effect similar to the nitride film of preventing the diffusion of oxygen, it is considered that the effect of preventing the diffusion is caused with respect to copper (Cu) also.

[0040]

In this manner, it should be understood that the present invention involves various embodiments not mentioned here. Accordingly, the present invention is restricted only by

inventive specific claims pertaining to the proper claims from this disclosure.

[0041]

[Effects of the Invention]

As described above, according to the present invention, it is possible to provide the semiconductor device in which the reflow process of the BPSG film in the vapor atmosphere can be carried out with respect to the semiconductor device which has a problem on hydrogen in the nitride film and cannot form the nitride film.

[0042]

According to the present invention, it is possible to provide the method for manufacturing the semiconductor device in which the reflow process of the BPSG film in the vapor atmosphere can be carried out with respect to the semiconductor device which has a problem on hydrogen in the nitride film and cannot form the nitride film.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a sectional view of a semiconductor device according to a first embodiment of the present invention;

[Fig. 2]

Fig. 2 is a diagram showing a nitrogen concentration in a nitrogen-containing oxide film and a distribution in a depth direction of the number of count of oxygen secondary ions in the semiconductor device according to the first embodiment of

the present invention;

[Fig. 3]

Fig. 3 is a diagram showing a relationship between an oxidizing amount of a silicon substrate and a nitrogen peak concentration in the film by a reflow process in the semiconductor device according to the first embodiment of the present invention;

[Fig. 4]

Fig. 4 is a diagram showing a method for manufacturing the semiconductor device according to the first embodiment of the present invention;

[Fig. 5]

Fig. 5 is a diagram showing a relationship between a film forming time of a nitrogen-containing oxide film 6 and the nitrogen peak concentration in the film in the semiconductor device according to the first embodiment of the present invention;

[Fig. 6]

Fig. 6 is a diagram showing a method for manufacturing a semiconductor device according to a second embodiment of the present invention;

[Fig. 7]

Fig. 7 is a sectional view of a semiconductor device according to a third embodiment of the present invention;

[Fig. 8]